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CONTENTS

Temperature curves for killing potato tubers by heat ..... E. S. Schultz and C. H. Bloomquist 605

Relation of crown gall ..... Marguerite T. Cook and Carl B. Ja[illegible] 611

Susceptibility of tomatoes to [illegible] ..... Carl B. Ja[illegible] 623

Serial genomic host of [illegible] solanaceæ[illegible] ..... Cooke G. Willes and Eduardo F. Rodrigues 627

Brief history of [illegible] in Japan ..... Tokasaburô Tanaka 633

Cytology of the Sclerotinia on Echinochloa crus-galli ..... Shigeo Sawada 639

Fungus isolated from the interior of cotton seed ..... R. E. Crawford and [illegible] 645

Abstracts of papers presented at the annual meeting of the American Phytopathological Society 654

Abstracts of Papers Presented at the First Annual Meeting of the Inland Empire Section, Pacific Division, American Phytopathological Society, Pullman, Wash., and Spokane, Idaho, February 3 and 4, 1923 664

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PHYTOPATHOLOGY

VOLUME XIII NUMBER 11

NOVEMBER, 1923

TIME-TEMPERATURE CURVES FOR KILLING POTATO TUBERS BY HEAT TREATMENTS

F. M. BLODGETT

WITH THREE FIGURES IN THE TEXT

The mosaic and leaf-roll diseases of potatoes were early found (8) to be transmitted from year to year by means of the tubers. Since none of the disinfecting solutions used experimentally or in practice has shown the slightest indication of reducing the amount of either of these diseases, and since they may be transmitted by using the juice of diseased plants (4), it may be accepted without much question that the disease producing agent is internal in the tuber. Some method of heat treatment, therefore, would be indicated as offering possibilities of success. The experiments reported here were conducted with particular reference to the two diseases mentioned. Experiments were made both by treating potatoes in a hot water bath and in a hot air oven. Advantage was taken of the opportunity thus offered to formulate an approximation of the conditions of time and temperature necessary to kill potatoes by such treatments. This is believed to be worth recording both as a guide that may be used in the treatment of potatoes by these methods for other diseases and as indicating the conditions under which potatoes may be injured in storage or transit. It is hoped also that the results presented here may give some clue to the effect of varying the temperature in other seed treatments.

The plan was to make experiments over as wide a range of temperatures as practicable. At each temperature selected, treatments were made over a range of time intervals from comparatively short treatments up to treatments long enough to kill the potato. This was deemed necessary and desirable since it is easily conceivable that the time-temperature death curve for the potato might cross the time-temperature death curve for the infective agent of mosaic. Thus the potato might be killed more quickly at one temperature and the infective agent of mosaic more quickly at another temperature. That this is possible is indicated by the results of Miss Chick (3) in the killing of bacteria by hot water. She found that the velocity of disinfection is increased more than 100-

fold per 10° C. rise in temperature in case of *B. typhosus*, 29-fold per 10° C. for *Staphylococcus pyogenes*, and 12-fold per 10° C. for *B. Coli*.

After the treatments, the potatoes were labelled and stored at laboratory temperatures where they either sprouted in a short time or if killed by the treatment dried up or rotted. They were inspected from time to time. If they sprouted a record was taken of the approximate kind and amount of sprouting and the potatoes were planted in the greenhouse to see whether they produced leaf-roll or mosaic plants, according to whether the seed treated was taken from mosaic or leaf-roll plants. If the potatoes were killed by the treatment no effort was made to determine whether the virus was still infective or not. This would have been desirable but the methods of inoculation so far tried did not seem certain enough to make the attempts worth while.

In this manner, the time necessary to completely kill potatoes was sought at each temperature at which tests were made. The time finally accepted as the one sought was one midway between the treatment where the last potatoes sprouted and the first in which no sprouting occurred. This is clearly only an approximation both because the end point is not sharply defined and because the end point found is more or less dependent on how near together the intervals selected for treatment are in this neighborhood.

HOT WATER TREATMENTS

The hot water treatments were made in a water bath in tap water, heated by an electric heater under thermostatic control. Mechanical agitation was supplied in all the later tests.

In making the treatments it was found better to place the potatoes in the bath a few at a time at such intervals that they could be removed all at once to give the series of treatments at the desired intervals. In this way the temperature of the bath was not measurably disturbed by the addition of potatoes.

A sample of the data recorded in one test is given in table 1. A series of twenty-eight such tests were made at different temperatures varying from 34.5° C. to 80° C. A summary of these tests is shown in table 2. As shown in table 1, the end point at 55.5° C. lies between 22 and 26 minutes. In making up summary table 2 the midpoint between these two times, i. e., 24 minutes was chosen as representing the time for killing as nearly as possible from the data at hand.

It is to be noted that the potatoes used in different tests differed in age and variety but the results were so uniform that they are all considered together.

TABLE 1.—*Hot water treatment at a temperature of 55.5° C. of blue sprout potatoes affected with leaf-roll.*

Length of treatment	Conditions of potatoes				Progeny
	Mar. 21	Apr. 7	May 15	July 26	
0 min.	sprouted	sprouted			Leaf-roll
2 "	"	"			" "
4 "	"	"			" "
8 "	"	"			" "
14 "	not sprouted	not sprouted	slender sprouts		" "
16 "	"	"	one sprout		" "
18 "	"	"	firm no. sprouts		
22 "	"	"	"	4 weak sprouts	" "
26 "	withered	dead			
32 "	dried up	"			
40 "	black shrunken				

The results are also shown in figure 1 in which temperatures in degrees Centigrade are plotted as abscissas and the logarithms of the times in minutes are plotted as ordinates. When plotted in this way, the points seem to approximate a straight line so that the relation of time to temperature in the killing of potatoes may be expressed by one of the standard forms of equation of the straight line as

$$y + mx + b = 0$$

in which y equals the logarithm[1] of the time and x is the temperature in degrees Centigrade. When this was fitted by the method of least squares the following values were found for the constants m and b.

$$m = .09552 \pm .0026$$
$$b = -6.5896 \pm .0191$$

The equation

$$y + .09552x = 6.5896$$

[1] Wherever logarithms appear in this article the common or Brigs system is used.

TABLE 2.—*Time required to kill potatoes at different temperatures in a water bath.*

Temperature in degrees Centigrade	Time in minutes	Disease	Variety	Date
34.5	2310	Mosaic	Bliss	5/9/21
35	2370	"	"	5/16/21
35	2700	"	"	5/3/21
40	480	"	"	5/6/21
40.5	495	Leaf-roll	Rurals	2/10/22
41	570	Mosaic	Bliss	7/14/21
44	370	Leaf-roll	Rurals	2/16/22
50	60	Mosaic	Bliss	3/24/21
50	60	"	"	3/3/21
50	45	"	"	3/11/21
49.7	47.5	Leaf-roll	Rurals	2/7/22
55.5	24	" "	"	2/23/22
56	10	Mosaic	Bliss	5/3/21
59.5	10	"	"	7/3/21
60	4.25	"	"	3/24/21
60	11	"	"	3/4/21
60	12	Leaf-roll	Rurals	2/22/22
65	1.12	Mosaic	Bliss	4/12/21
65	1.25	"	"	3/25/21
25.8	2.00	Leaf-roll	Rurals	2/23/22
70	.25	Mosaic	Bliss	7/25/21
75	.66	"	"	7/22/21
80	.266	"	"	7/25/21

is therefore offered as an empirical approximation of the relation of the time and temperature for killing such potatoes in hot water treatments. The potatoes used in these experiments came from definitely diseased plants either of mosaic or leaf-roll as indicated. The behavior of perfectly healthy tubers, therefore, can not be stated certainly from these tests but judging by the work reported by McCurry (5) and by the results reported later in this paper under hot air treatments it is altogether probable that the curve or equation as given above represents the conditions under which healthy potatoes are killed very nearly if not quite as well as for diseased tubers.

The deviations of some of the killing points found from this line are rather wide but the deviations seem to be random variations rather than a tendency for the points to curve away from the line in any part of it. They are, therefore, attributed to errors in observation and particularly to the rather indefinite end point. The errors are largest at high temperatures where the time intervals for killing are very short and more difficult to measure accurately by the method used.

Since the method of fitting the curve is essentially a method of averaging all the observations, it seems reasonable to suppose that the curve or the equation of the curve represents the time necessary to kill the potatoes at any given temperature better than any single observation made at that temperature. They also fairly represent what may be expected at intermediate temperatures at which no observations were made.

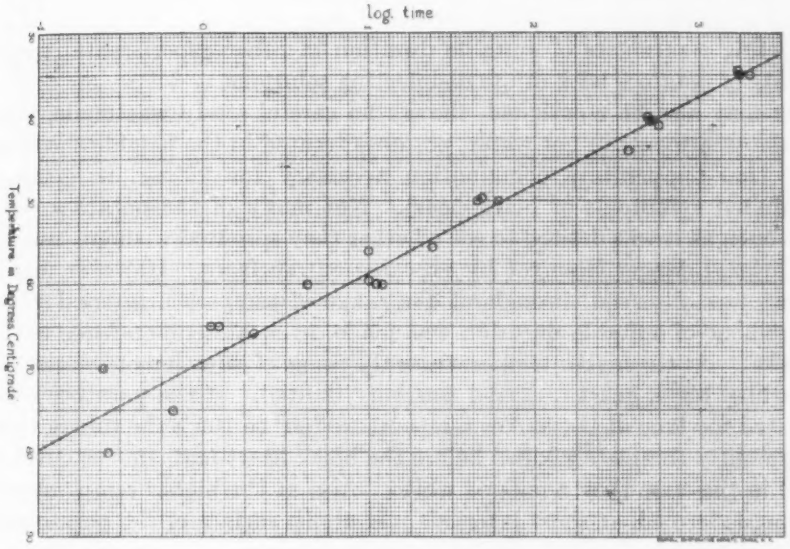

FIG. 1. Graph showing time (expressed as log time in minutes) required to kill potatoes when treated at different temperatures in hot water.

In the equation of this curve the constant m represents the slope of the curve or the amount of change in the logarithm of the time for one degree change in temperature. This would be equivalent to changing the time by multiplying it by the antilogarithm of m for each degree of lowering of the temperature, i. e., by 1.246, for a lowering of two degrees by $(1.246)^2$, for a lowering of 10 degrees by $(1.246)^{10}$ or 9.02.

To illustrate, it may be calculated from the equation that at 70° C. potatoes are killed in about .8 of a minute. If the temperature is lowered by 10° to 60° C. the time is $9.02 \times .8$ or 7.218 minutes. At 50° the time is 65.1 minutes and at 40° it is 58.72 minutes.

A similar relation was found by Miss Chick (3) between time and temperature in the killing of *B. Typhosus* by hot water. Bigelow (2)

has also found that this type of curve resulted when the thermal death times were determined for fifteen thermophilic bacteria. The writer has also found indications that similar results are to be expected in killing potatoes in mercuric chloride solutions, though the experiments so far made have not been very extensive.

So far as the work with dilute mercuric chloride solutions has progressed, it may be said that the time temperature curve for killing potatoes seems to be a little below the hot water curve and approximately parallel to it. This suggests that the hot water curve may serve as a rough guide in selecting treatments of suitable duration in other experimental treatments of potatoes with dilute disinfecting solutions.

It may also be mentioned, though no careful study was made, that in the treatments in hot water, potatoes treated in the neighborhood of the time-temperature combination necessary for killing, in general, exhibited symptoms of black heart. Not many of the potatoes were cut open as it was desired to see whether they sprouted without causing additional danger from rot by exposing cut surfaces. However, black heart was observed throughout the range of temperatures tried when treatment of suitable duration was made, even at temperatures up to 100° C. At the higher temperatures the range of duration of treatments in which black heart occurred was very limited. If the potatoes were treated too long at the higher temperature (60° to 100°) the tubers were apparently completely killed before the black heart had time to develop and in this case they remained white. Also at the higher temperatures a ring is formed, at short intervals just at the surface of the potato and at increasingly longer treatments the ring grows smaller and smaller until finally a dark spot only is formed at the center of the potato. Presumably the part outside the ring is killed so quickly that it remains white while the part inside has not been treated long enough to bring about this reaction.

TREATMENT OF POTATOES IN A HOT AIR OVEN

After most of the treatments of potatoes in hot water had been made, it was noted that the time necessary to kill potatoes in this manner was much shorter than the time necessary to kill potatoes in a hot air oven as reported by Pethybridge (7) and by Bartholomew (1) at temperatures where comparisons could be made. Therefore, it seemed desirable to make some treatments in a hot air oven for comparison. It appeared not impossible that the killing of the potato or of the virus of mosaic would be brought about by a sufficiently different reaction so

that the virus could be destroyed by this method without killing the potato even though the hot water method had failed.

The general methods used were similar to those used in the hot water treatments. The potatoes were suspended in a Fries hot air oven by cotton strings to avoid contact with metal. The air in the oven was kept in circulation by means of an electric fan. The potatoes used were mostly affected with mosaic, though a few treatments were made with healthy potatoes. The potatoes which sprouted after the treatments were planted in the greenhouse. All potatoes that were known to be affected with mosaic before treatment gave rise to mosaic progeny when planted. From the standpoint of the control of mosaic, then, this treatment is a failure.

By the same method as in the hot water treatment a summary of the killing of potatoes in a hot air oven was prepared. These results are given in table 3 and also shown in figure 2. In this case plotting the

TABLE 3.—*Time required to kill potatoes (variety Magnum Bonum) in a well ventilated hot air oven at different temperatures.*

Temperature in degrees Centigrade	Time in minutes	Conditions of potatoes	Date
35	187200	Mosaic	3/30–9/11/22
40	6300	"	8/14/22
45	1980	"	3/23–24/22
50	270	Healthy	3/20/22
60	77.5	"	3/21/22
60	55.5	Mosaic	8/23/22
65	32.5	"	8/24/22
70	29	"	8/29/22
70	35	Healthy	3/20/22
70	32.5	Mosaic	3/22/22
80	19	"	3/25/22
90	20	"	3/28/22
100	11	"	4/7/22
120	10	"	3/29/22

logarithms of times as ordinates and the temperatures as abscissas does not give a straight line curve but proves to offer a convenient scale to work with where so wide a range of times are involved. Also a comparison may be made directly between the two treatments when they are both plotted in the same way.

A general expression was sought that would represent empirically at least the length of treatment necessary to kill potatoes throughout the range of temperatures at which tests were made. After numerous trials

of different curves, it was found that a curve represented by an equation of the form

$$(y - a)(x - c)^3 = b$$

could be made to fit the points as plotted as closely as could be reasonably expected considering the obvious irregularities in the observations. In the above equation x is temperature in degrees Centigrade and y is time of treatment in minutes necessary to kill potatoes. In determining the values of the constants, c was approximated by substituting pairs of values of x and y found experimentally and eliminating a and b between three such equations and solving for c. This was done several times with

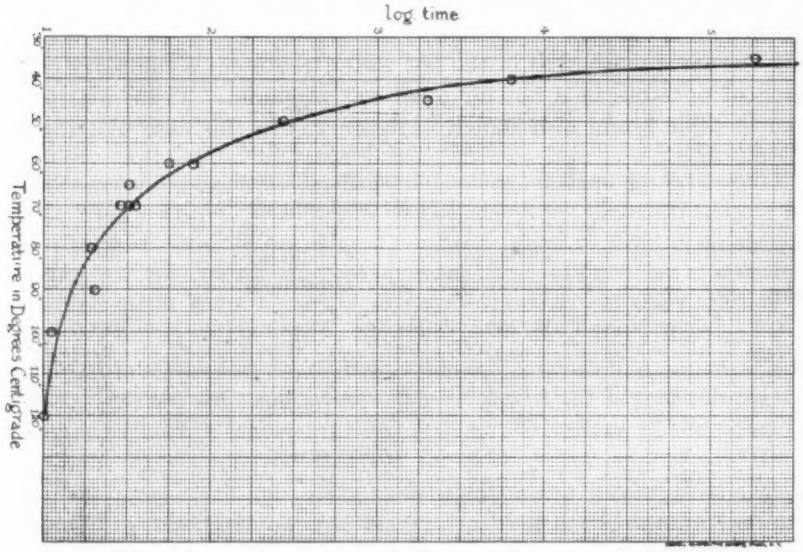

FIG. 2. Graph showing time (expressed as log time in minutes) required to kill potatoes when treated at different temperatures in a well ventilated hot air oven.

different series of pairs of values of x and y. The average value for c thus found was taken. Values were then found for a and b by the method of least squares. In this way the following values were found for the constants.

$$a = 8.4255$$
$$b = 1057500$$
$$c = 34.5$$

The curve as drawn in figure 2 represents this equation. Since the eye can judge better as to whether a straight line fits a series of points the same results are plotted in figure 3 with log $(y - 8.4255)$ as or-

dinates and log $(x - 34.5)$ as abscissas. This curve is plotted with a slope of minus three and the fit of the observation points to this curve serves to confirm the exponent three of the quantity $(x - c)$ which was somewhat arbitrarily chosen. The observation points seem to fit this curve as well as might reasonably be expected except the point representing an observation at 35° C. The accuracy of this observation is indeed open to question for various reasons.

Probably too much significance should not be attached to the constants of an equation thus empirically found, particularly when they apply at

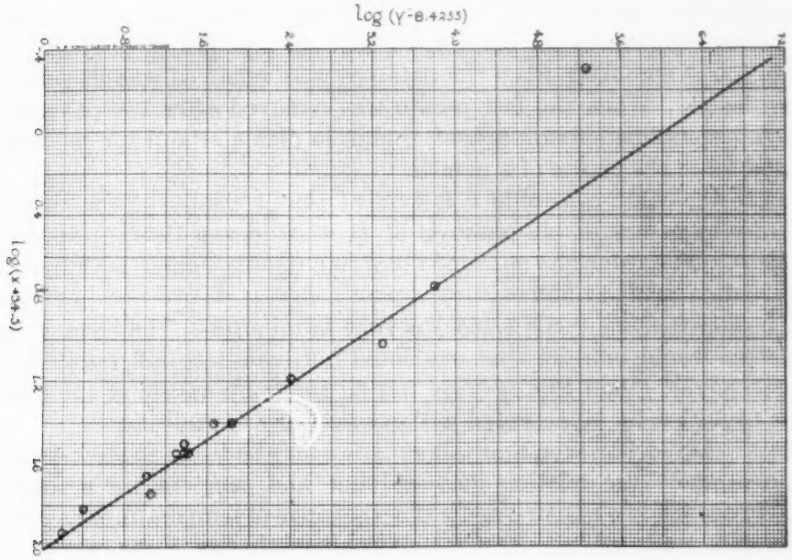

FIG. 3. To test further the fit of the equation $(y - 8.4255)(x - 34.5)^3 = 1057500$ it was changed to the form $\log (y - 8.4255) = \log 1057500 - 3 \log (x - 34.5)$ In this graph logs $(y - 8.4255)$ are plotted as ordinates and logs $(x - 34.5)$ as abscissas to show how closely a straight line is approximated.

temperatures outside the range in which tests were made as in the case of *a* or at the extreme end of the range as in the case of *b* and *c*. However, this does not invalidate the use of the equation with the values found for the constants substituted in it for the purpose of calculating approximately the time necessary to kill potatoes by such treatments at any temperature within the range studied.

Furthermore, it is evident that there must be a limit in temperature in the neighborhood of 35° below which potatoes will sprout and above

which they will be injured. From the form of the equation it is clear that the curve approaches the line $x = c$ asymtotically and thus c (found to equal 34.5) is an approximation of the limit of temperature in degrees Centigrade below which potatoes are not killed by such treatments.

In this connection the behavior of potatoes treated at 35° C. is interesting. When the potatoes were placed in the chamber at this temperature, they already had short sprouts about one half centimeter long. As long as they remained at this temperature no perceptible growth of sprouts occurred but as they were removed from time to time sprout growth was resumed. However, as the potatoes remained longer up to several months the old sprouts took on a yellowish color and resumption of sprouting when the potatoes were removed was slower and more feeble. When the last potato was removed after 130 days only two fine spindling sprouts (about .8 mm. in diameter and 1.5 cm. long) developed in the course of a month.

As to the other constants it is evident that b should be the time in minutes necessary to kill potatoes at $(1 + c)$ degrees Centigrade, i. e., at 35.5°. The value of b as found (1057500) does not agree with the one observation made at 35°.

The constant a (equals 8.4255) is time in minutes. The form of the equation would indicate that one could not expect to kill potatoes in shorter periods than this even by raising the temperature of the oven. This could hardly be accepted without further experiments.

It is believed, however, that this equation may be taken as representing approximately the relation between time and temperature necessary to kill potatoes in a hot air oven within the range of temperatures at which tests were made (35° to 120° C.). It is hoped that as in the case of the treatment of potatoes in hot water it will indicate the limit beyond which it is unsafe to go in treating potatoes for any parasitic disease by this method. In fact, it can not be approached very closely without serious injury to the potatoes.

This curve may also be taken as an indication of conditions under which injury may be expected to potatoes in storage or transit. However, it is probable that the times represented on this curve apply only to well ventilated potatoes as the ventilators were kept open on the oven used. It has been shown by Stewart and Mix (9) that lack of air brings about a similar injury at low temperatures. Such heat injury to potatoes is apparently not uncommon in certain places. In a report by Mann and Nagpurkar (6), they state that when potatoes were stored in a well aerated room, in a place where the shade temperature went up

to cover 100° F. in a few days, a large part of the stock became rotten and useless. They also state that there is no danger in storing potatoes below 86° and little danger below 90° F. General rotting has also been reported at times in potatoes transported in the holds of ships, which seems to merit investigations along these lines.

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EARLY STAGES OF CROWN GALL

MELVILLE T. COOK

WITH FOURTEEN FIGURES IN THE TEXT

The study of plant galls due to various causes has resulted in the accumulation of much interesting data but very naturally many points have been overlooked. In general it may be said that plant galls follow the same general lines of development regardless of cause of formation. This very general statement may be analysed as follows:—(1) The excitation or stimulant must be applied to the meristematic tissue. In the case of some galls caused by insects, the experimental work indicates that the stimulant must be applied to the primary meristem or cambium. In the case of crown gall it has been claimed that the tissues other than the cambium were susceptible to stimulation but these statements are far from being definite. (2) The first result of this stimulation is the formation of a homogeneous parenchyma tissue instead of the normal differentiation of tissues which is characteristic of the normal organ. In some cases this homogeneous tissue is characteristic of the various species of galls. (3) It is doubtful if any tissue, having become fixed, can be stimulated into activity; but it is evident that some tissues, which under normal conditions are fixed, may be stimulated into activity. (4) It has been demonstrated in a large number of cases that the cell activity may be in cells which are very remote from the organism and is due to some secretion which passes from cell to cell or to mechanical pressure resulting from the growth of neighboring cells.

This study of the crown gall was undertaken to determine the incipient stages of formation. However, some other data were incidentally acquired. The material used was castor oil bean seedlings about four inches in height and young plants of Bryophyllum, although most of the studies were made on the former. The inoculations were made into slits just below the cotyledons. Longitudinal slits were used instead of needle punctures in order to make sure that the organisms came in contact with all tissues from epidermis to central parenchyma pith. These slits were filled with the organism from cultures.[1] In making inoculations with a needle it is very evident that some of the organism may not penetrate to the depth of the needle point. However, a slit is a much more severe wound and probably causes a much greater shock

[1] The original culture was furnished me by Dr. Erwin F. Smith of the U. S. Bureau of Plant Industry.

to the growing plant tissues than a needle prick. In order to determine just how much of the reaction was due to the organism and how much was due to the wound, plants of approximately the same age were cut in the same manner with a clean, sterilized scalpel and held as checks. Of course it was impossible to make the slits exactly the same; some of the slits would pass through the fibro-vascular bundles while others would follow the medullary rays. At intervals of two days the slit regions of both the inoculated and check seedlings were cut into small pieces, fixed in weak Flemming fluid, embedded, cut and stained with haematoxylon-iron alum and safranin-gentian violet. Both the inoculated and check material were studied in comparison with tissues from an uninjured plant.

There is nothing unusual in the structure of the normal seedling castor bean. It is that of the ordinary herbaceous, dicotyledonous plant. It may be briefly described as follows:—epidermis with thin cuticle, a cortex consisting of about 12 or 15 layers of parenchyma cells which become larger in passing inward but which show little or no signs of collenchyma formation; distinct phloem, cambium, xylem, and pith; each consisting of the characteristic cell structures (figures 2 and 4).

The reaction to the wound may be described as follows:—an increase in the number of layers of cortex cells in the vicinity of the wound, thus forming the callus (Fig. 1, ca); sometimes a slight stimulation of the phloem dependent on the location of the injury; sometimes an increase in thickness of the cambium; a distortion of the xylem due to the growth of other tissues when the knife passes through a young fibro-vascular bundle (Fig. 5); a growth of medullary ray and pith parenchyma to form rows of cells (Fig. 3). Of course since reactions of this kind occur in uninoculated plants they cannot be attributed to the organism in the case of those plants which were inoculated.

In the case of the inoculated plants we find exactly the same reactions as in wounded plants, before we find any reaction which the writer was satisfied in attributing to the organism. Reasoning from our knowledge of other plant galls it was natural to expect the most pronounced reactions would be in the cambium, but such was not the case. The first reaction observed which the writer felt justified in attributing to the organism was in the cortex, or outer part of the medullary ray, i.e., between the phloems of two adjacent bundles. It was in close contact with the cambium (Fig. 6), and slightly removed from the point of inoculation. This was a mass of cells which the author will designate as a "whorl." It has been previously designated as a "whorl" and as a "nest" by Dr. Erwin F. Smith. It consists of cells which were richer

in protoplasm than the surrounding cells and more of them showed nuclei although none were multi-nucleate. They showed indications of growth in that some of them were larger and some smaller than the surrounding normal cells, the larger ones apparently having been stimulated into excessive growth and the smaller ones into excessive cell division. Although the whorl was clearly evident, the cells graded into the surrounding cells, so that it was difficult to determine an exact outline. Most of the cells, and sometimes all that are visible in a section, undergo repeated divisions, so that in many sections all the cells of a "whorl" are small, rich in protoplasm and each provided with a single nucleus (Fig. 7). In longitudinal section, these "whorls" have the same appearance, so that in reality they are very nearly spherical masses. The crown gall appears to be made up of one or more of these "whorls" or masses. It was at first supposed that these masses were restricted to the cortex but they were later found in considerable abundance in the pith. However, it appears from these studies that the cortex, which is in close contact with the cambium, is most favorable for the development of these "whorls."

The tracheary tubes of the fibro-vascular bundles were frequently pushed out of place by the mechanical pressure exerted by the "whorls," but there was no evidence to indicate that they were ever directly influenced or modified by the organism (Fig. 5). However, tracheids were very generally formed in the whorls and apparently directly from the parenchyma cells (Fig. 8). In some cases the nucleus and some protoplasm were still visible in these tracheid cells (Fig. 9). Instead of being arranged in more or less straight, perpendicular lines as in normal stems, they were placed in a very irregular manner. Later in the development of these "whorls," spiral tracheary tubes were formed. They also were apparently formed *de novo* from the homogeneous parenchyma of the "whorls" and not from the fibro-vascular bundles.

The strands of cancer tissue which have been described by Smith were very easily observed in both pith and cortex. Those in the pith were of greater diameter than those in the cortex; the distal end was blunt and resembled the whorl structure previously referred to (Fig. 10). The result of pressure on the surrounding cells was very evident, especially on those cells lying between the strands and the fibro-vascular bundles as shown by the formation of tracheids (Fig. 10). The strands in the cortex appeared to be formed from both cortical and cambium cells, and in every case observed, were between the phloem of two adjacent bundles (Fig. 11). The direction of growth was both up and down the stem. From time to time these strands push outward,

forming cone shaped masses of cells which finally break through the cortex and epidermis (Figs. 12–14). There is none of the "whorl"-like structure previously referred to but the cells are small. At first, this cone shaped body appears to be composed entirely of cells formed from the cortex and cambium but a little later, the pith (or probably more properly the medullary ray tissue) pushes or grows up from below and forms the center of the new or secondary gall (Figs. 13 and 14). Before the tip of the new gall has broken through the epidermis, tracheids are being formed in the base of the gall, apparently from the pith parenchyma cells (Fig. 14).

The galls very soon reach a degree of complexity in which the distortions are so great that it is sometimes impossible to tell just which tissues are of abnormal development and just which ones have been pushed out of place by the growth of others.

The sections showed the organism in abundance in the original slits and sometimes in small pockets connected with the slits but the writer was unable to trace the organism to the "whorl" or strands.

The studies show that the primary meristem or cambium does not respond to stimulation from the organism so quickly as in the case of many other galls. It is furthermore apparent that all meristematic cells may respond to stimulation from the organism. The question naturally arises as to when the cells cease to be meristematic. We will not attempt to answer this question, other than to say that the tracheary tissues have apparently ceased to be meristematic and that they are influenced only in so far as they may be pushed out of their normal position by the pressure exerted by the growth of neighboring tissues.

The cells of the incipient gall are parenchyma, are rich in protoplasm and are uni-nucleate. The only noticeable variation was in size of the individual cells. The tracheary tissues arise from these parenchyma cells.

The young shoots of *Bryophyllum* have a much weaker fibro-vascular bundle than the seedling plants of castor oil bean, the cortex is somewhat thicker and the pith more prominent. The response to a slit wound is very similar; the cells of the cortex and pith tend to arrange themselves in rows but the distortion of the fibro-vascular bundle is much more prominent. In the case of those plants which were inoculated the whorls were formed in practically the same manner as in the castor bean but in some cases the connection with the cambium was much more pronounced.

In order to determine the question of response of tissue to the organism, fourteen nodes of a growing shoot were inoculated beginning with the outermost. Well defined galls developed at the six outermost

nodes. Sections through the other nodes showed evidence of cellular disturbances which would probably have developed into galls at a later date.

SUMMARY

The stimulation is not restricted to the cambium.

Parenchyma tissue is especially susceptible to stimulation.

The galls start as more or less spherical masses in the parenchyma cells which are stimulated into activity. The growth is different from the callus growth following wounds.

The organism evidently exerts considerable influence in cells with which it is not in contact.

The xylem of the fibro-vascular bundle may be distorted as a result of a wound or as a result of pressure exerted by growing gall tissues but it is doubtful if it is otherwise modified.

Tracheids and spiral tubes appear in the galls but are evidently developed *de novo* from homogeneous parenchyma mass of the incipient gall.

Tumor strands may develop in the pith or in the cortex in close contact with (or possibly involving) the cambium. These latter strands lie between the phloem of the two adjacent fibro-vascular bundles.

The author wishes to express his thanks to the New York Botanical Garden for facilities and use of the library in conducting these studies and to members of the staff for assistance in many ways.

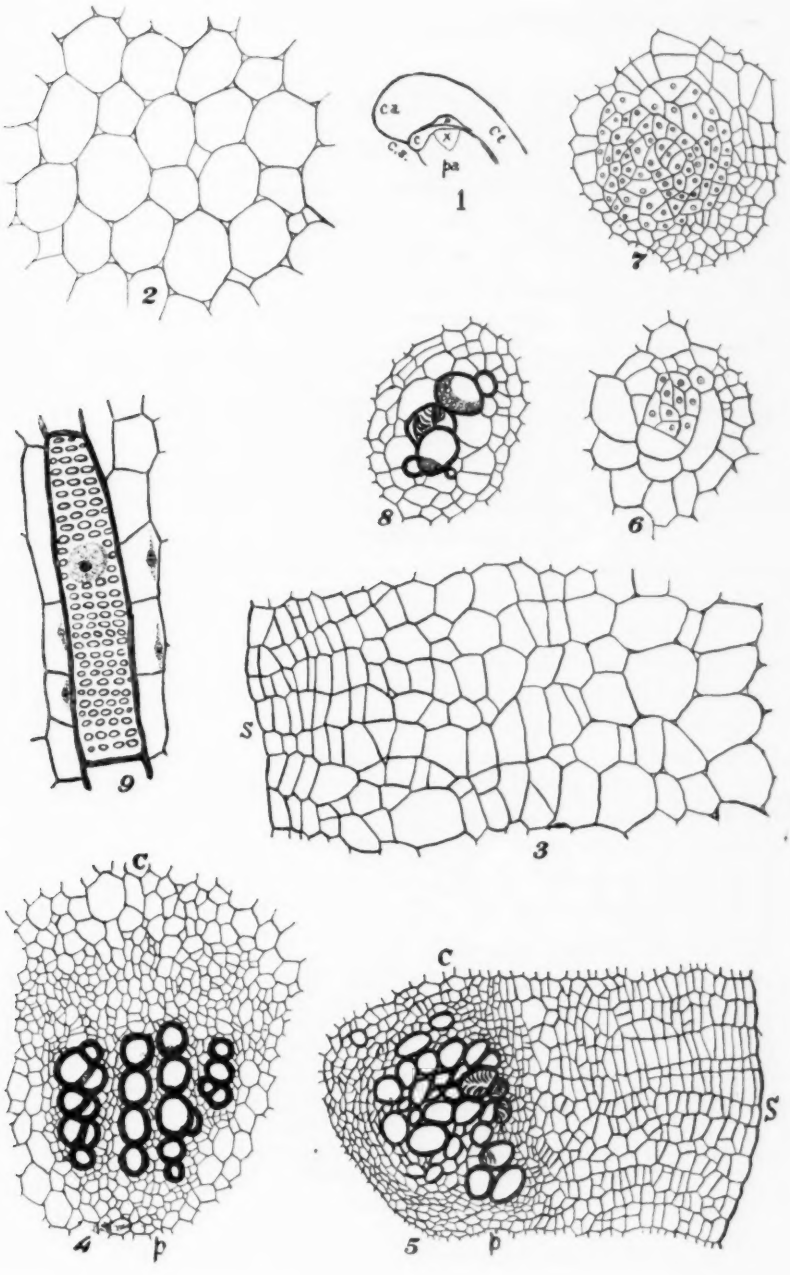
INSULAR EXPERIMENT STATION,

RIO PIEDRAS, PORTO RICO.

EXPLANATION OF FIGURES

All drawings were made from sections of castor bean seedlings.

FIG. 1. Diagrammatical drawing of part of cross section. c.s.—cut surface; pa—parenchyma of pith; c—cambium; x—xylem; ct—cortex; ca—callus. FIG. 2. Normal parenchyma cells from pith. FIG. 3. Cross section of pith parenchyma showing tendency for arrangement of cells in rows following a wound. s—cut surface. FIG. 4. Cross section of normal fibro-vascular bundle. c—cortex side; p—pith side. FIG. 5. Cross section of fibro-vascular bundle showing distortion. s—cut surface through medullary ray; c—cortex side; p—pith side. FIG. 6. Young "whorl" in cortex, in close contact with cambium, and between the phloem of two adjacent bundles. FIG. 7. Older "whorl" in cortex, in close contact with cambium. FIG. 8. "Whorl" showing the formation of tracheary tissue. FIG. 9. Tracheid cell in which the nucleus is still visible. FIG. 10. The tumor strand in the pith, showing the advancing tip. Also showing the formation of tracheary cells apparently as a result of mechanical pressure. FIG. 11. Diagrammatical cross section drawing showing position of secondary tumor arising from cortex intermediary between two fibro-vascular bundles. s.t.—secondary tumor; e—epidermis; f—fibro-vascular bundle; t—early formation of tracheary cells. FIG. 12. Drawing of part of section of secondary tumor apparently arising from the cambium; ca—cambium; c—cortex; e—epidermis. FIG. 13. Diagrammatical longitudinal drawing of secondary tumor. s.t.—secondary tumor; c—cortex; e—epidermis; ca—cambium. FIG. 14. Diagrammatical longitudinal drawing of slightly older secondary tumor. s.t.—secondary tumor; c—cortex; e—epidermis; t—region of early formation of tracheary tissue.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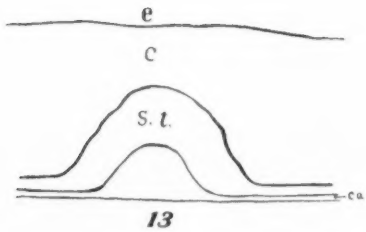

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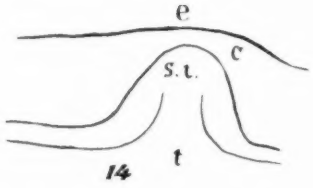

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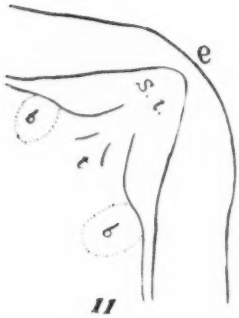

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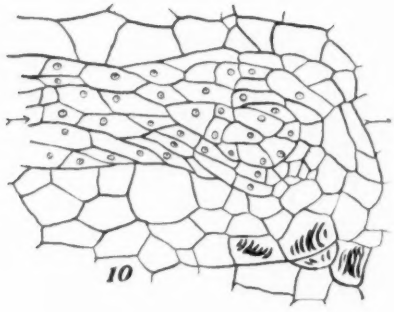

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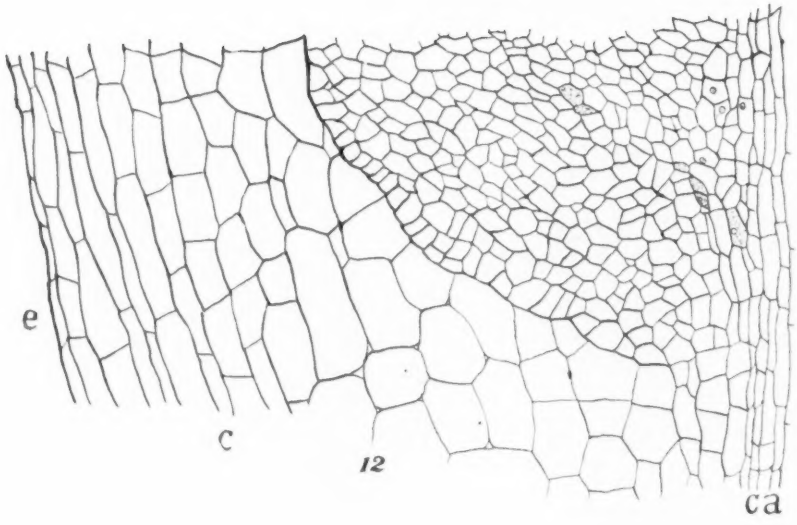

12

HELMINTHOSPORIUM HEVEAE IN SUMATRA

CARL D. LA RUE

Helminthosporium Heveae, Petch, a parasite of the Para rubber tree, *Hevea brasiliensis*, has been known in Ceylon, where it was described by Petch, for about fifteen years. As late as 1911 Bancroft[1] stated that there was as yet no record of the occurrence of this disease in the Federated Malay States. The writer has not seen any note of its occurrence in the Federated Malay States since that time, but according to Butler[2] the disease occurs in Malaya, as well as in Ceylon, South India, and Java. There is no record of this disease in Sumatra although it has doubtless existed there for some time. The observations of the writer are confined to the years 1917–1920, but the fact that the disease was already widely spread in 1917 indicated that it had been present for at least a few years previous to that time.

Both Petch[3] and Butler state that the disease is confined to young trees, that it does not cause defoliation, and that the damage is not severe.

Observations in Sumatra made in 1917 and 1918 by the author are quite in agreement with those of Petch and Butler. Spotting of leaves from the disease was seen to be very common in nurseries and in estates just planted. In some cases the spotting and malformation of the leaves have been the cause of considerable loss of vigor in the seedlings. After the first wintering, however, usually no traces of the disease could be found.

In 1919, on the contrary, the disease was found on old trees on several different estates; on one area several hundred trees were affected. The severity of the disease varied greatly on different areas and with different individual trees; on some it was confined to a few spots on some of the leaves, while in the worst cases almost every leaf was riddled with spots. Malformation of the leaves was commonly seen but was not pronounced in extent. The attack was especially noticeable just as the young leaves were coming out. Some of the affected trees were partly defoliated,

[1] Bancroft, Keith. The Dieback Disease of Para Rubber and a note on the Leaf Disease of Para Rubber. Fed. Malay States Department of Agriculture. Bull. 14.

[2] Butler, W. J. Fungi and Disease in Plants. Thacker, Spink & Co. Calcutta & Simla. 1918.

[3] Petch, T. The physiology and Diseases of Hevea Brasiliensis. Dulau & Co., Ltd., London, 1911.

but a careful examination indicated that the defoliation was due to the attack of mites rather than to the activity of the fungus.

INFECTION

Infection appears to take place in most cases while the leaves are still very small and not yet unfolded. With the growth of the leaves to a larger size still more spots are formed, but apparently almost no infection occurs after the leaves have reached full size and have become cutinized on the surface. Spotting occurs on the petioles and the midribs as well as on the laminas of the leaves. Spots on the bark of the twig are comparatively rare. The number of spots on a leaf varies from one or two to some dozens; in the worst cases one half or more of the assimilating area of the leaf is invaded by the fungus and killed or rendered useless. Where all or most of the leaves of a tree are so attacked the disease may be considered serious because of the interference with the food supply of the tree.

Evidence is lacking that the disease affects parts of the tree other than the leaf-blades and petioles, and occasionally the bark of the young twigs. Cultures of the tips of twigs, which bore infected leaves but which were not themselves spotted, did not show Helminthosporium, so it appears that the fungus does not enter the twigs from the leaves. Likewise it appears that the leaves are not infected by growth of the fungus from the twigs but by wind-borne spores.

The source of spores in this case was probably the leaves of the previous season which were seen to be more or less spotted. Given proper conditions for infection these old leaves could easily infect the new ones. It is not known whether the fallen leaves disseminate spores or not but the difference in time of wintering would allow a few diseased trees which winter late to infect a large number of trees just as the leaves unfolded.

It is probable that nurseries and estates are sometimes infected from crops planted by natives in their villages. The question of the susceptibility of the various common crops to Helminthosporium attack has not been investigated, but the writer has very often seen what appear to be Helminthosporium spots on Manihot and papaya. It is probable that the disease is harbored by several common plants, from which it can spread to rubber nurseries and plantations.

GROWTH OF THE FUNGUS IN CULTURE

The organism has been grown in culture by the author and has been found very easy of cultivation. On agar made with a decoction of

Hevea leaves and twigs it grows very well. It also grows satisfactorily on bouillion agar. Fruiting does not take place on either of these media until the culture is quite old and the agar rather dry. No special attempts were made to induce more rapid fruiting but it is likely that this could be done.

The mycelium of the fungus is at first white but soon turns dark on the surface of the agar, and after a short time nearly all the mycelium is dark in color with a white fringe around the outer edge.

The fungus when grown on raw potatoes failed to show active parasitism. A slight dry rot over a small area was the only development.

SIZE AND CHARACTER OF THE SPORES

The spores of the fungus when first formed are hyaline, curved, and non-septate. Later they darken and become vacuolate with several large vacuoles. Finally they are quite dark with rather evenly spaced septa. Sometimes the vacuolate condition of the spore persists, but whether or not the spores which remain in the vacuolate condition are viable is unknown. The description of the spots and spores of Helminthosporium, as given by Petch, fits the fungus in Sumatra very well except that the spores of the Sumatran form appear to be much smaller, especially when produced in culture. Petch gives the spore length as 100 to 200 microns while from 100 measurements of spores from one culture the following distribution of lengths was secured by the writer:

Spore lengths in microns	*Number of spores*
32.8	4
36.6	1
30.4	7
34.2	8
38.0	7
41.8	16
45.8	14
49.4	9
53.2	8
57.0	6
60.5	5
64.4	4
68.4	2
72.2	3
76.0	3
79.8	2
83.6	1
Range of spore length	22.8–83.6 microns
Mode of distribution curve	41.8 microns
Mean spore length	47.44 microns

Thus the largest spore measured from this culture is smaller than the smallest length given by Petch.

Eighty measurements of spores taken from a leaf of Hevea gave the following frequency distribution.

Spore lengths in microns	*Number of spores*
38.0	1
45.6	3
53.2	2
60.6	6
68.4	4
76.0	4
83.6	14
91.2	17
98.8	12
106.4	10
114.0	7

The spores grown on the host plants are much larger than those grown in the culture which was measured but whether the difference is due to cultural conditions or to difference in strains is not known. The former is possible as the culture was isolated more than a year before the spores from the Hevea leaf were measured. It is equally possible that the two sets of measurements represent distinct strains and that other strains may exist which are as large as those measured by Petch.

La Rue and Bartlett[1] were able to distinguish a number of strains in *Pestalozzia Guepini* Desm. and the multi-lineate condition of such organisms as the wheat rusts is too well known to need mention. The same condition doubtless exists in many other species of fungi not yet critically studied and *H. Heveae* may well be one of this number.

It is possible also that changes in environmental conditions from one year to the next may cause changes in spore size.

Petch gives the width of the spore of the fungus as 15–18 microns. Measurements by the author of width of 25 spores from a leaf of Hevea gave:

Width in microns	*Number of spores*
11.9	3
13.6	11
15.3	9
17.0	2
Mean spore width	14.28 microns
Range of width of spore	11.9–17.0 microns

[1] La Rue, Carl D. and H. H. Bartlett. A demonstration of numerous distinct strains within the nominal species Pestalozzia Guepini Desm. Amer. Jour. Bot. **9**: 79–92. 1922.

These measurements agree fairly well with those of Petch although Petch does not report any spores so narrow as some found here.

The spores from the Hevea leaf which were measured for length were also examined for number of septa. The distribution is as follows:

Number of septa	*Number of spores*
1	1
2	0
3	3
4	4
5	3
6	9
7	24
8	19
9	14
10	3
Mean number of septa	7.12

These figures are also close to those given by Petch, which are 8–11 septa. The range here, 1–10 septa, is much greater than that given by Petch but it is possible that he examined only the larger spores without taking a random sample. This may possibly have been the case with all his measurements while those of the writer were all made on spores taken at random.

SUMMARY

Helminthosporium Heveae Petch is more or less widespread in the whole of the eastern rubber plantation area. It has been known in Ceylon and the Malay Peninsula, and its range is now shown to include Sumatra where it occurs on the East Coast. It usually infests nurseries where Hevea trees are planted but in 1919 it attacked mature trees also. The spores of the fungus in Sumatra appear to be smaller than those measured by Petch in Ceylon.

ANOTHER ECONOMIC HOST OF BACTERIUM SOLANACEARUM

COLIN G. WELLES AND EMILIANO F. ROLDAN

WITH TWO FIGURES IN THE TEXT

During the month of February, 1921, a serious wilting of mature tañgo plants (*Chrysanthemum coronarium* Linn.)[1] occurred in the gardens of the College of Agriculture, Los Baños, Philippine Islands. The disease persisted until May 1, when all of the plants were killed or so seriously affected that death was imminent.

The senior writer, while in China, learned that *C. coronarium* is used daily by most Chinese families from Canton as far north as Shanghai. The Cantonese name given to the plant is *tung-hao*. From the Chinese name the Tagalogs have derived the local name *tañgo*.

The college gardens have been known to be infested with *Bact. solanacearum* E. F. S. for several years, and because of this fact the wilt of tañgo was believed to be caused by the above named organism. On this hypothesis the following work was undertaken.

In a brief note the writers (1) have given, previously, a description of the disease and have stated that it was believed that *Bact. solanacearum* was the cause.

SYMPTOMS

The wilt of tañgo appears very similar to wilt of solanaceous plants caused by *Bact. solanacearum*. The seedlings are highly susceptible and are entirely destroyed within three days after the first appearance of the wilt, particularly in the dry season. The older leaves are diseased first and shortly thereafter the younger leaves become prostrate.

[1] *Chrysanthemum coronarium* Linn. is a plant of Mediterranean origin. Dean Charles Fuller Baker of the College of Agriculture, Los Baños, has very kindly offered the following information concerning the cultivation of this plant. To his knowledge it is cultivated in Cuba, and other islands of the West Indies, Philippine Islands, Straits Settlements, Borneo, and all other South Sea Islands which he has visited.

The following is taken from *The Commercial Products of India* by Sir George Watt: "This cultivated little herb is of interest mainly because of the fact that from Dinajpur and Rangpur in Bengal, north-east to Assam, it is extensively eaten, and is number 15 in Buchanan-Hamilton's list of saga or pot-herbs . . . . Plants of the pea family become scarce but . . . a peculiar series of pot-herbs take their places. Among these *C. coronarium* was found to hold a foremost position, being known as *babir* in North Bengal, *babui* in Assam, and *jalyniar* in the Khasia hills. Speaking of Formosa, Walters calls it *tan-ei-tsai* and adds that it is a 'herb much used by the Chinese as an article of food.' Bretschneider makes mention of two species of Chrysanthemum as known to the Chinese classics, the leaves of one of which are boiled into soup."

The older plants, while very susceptible to wilt, resist for several days before the leaves wilt and die. These older plants have thick, woody stems which support the wilted, dry leaves until intentionally destroyed.

ISOLATION OF THE ORGANISM

The vascular elements, and to some extent the parenchymatous tissue in severe attacks, appear packed with motile bacteria.

FIG. 1. Healthy and wilted tañgo plants. The plant to the left was inoculated through needle pricks in the stem about one week previous to the taking of the photograph. Both plants were held in the damp chamber for the entire period. The plants are half grown.

Isolations were made from sections of diseased stems and petioles, and a white organism was obtained in nearly pure culture. Transfers were made to nutrient and potato agar and from these, inoculations were made into tañgo seedlings.

INOCULATIONS

Seedlings of tañgo when inoculated with a young culture of the isolated organism, by needle pricks in the stems, wilted after varying periods depending on the age of the plant and its treatment after inoculation. The time of incubation fell between ten and twenty days. The periods

were shorter when the plants were held in a moist chamber and longer when inoculated in the field. When older plants were inoculated, wilt never developed unless the plants were kept in a damp chamber.

In each case where the plants were diseased the bundles of the stem were examined and were found always to be teeming with bacteria. In several cases re-isolations were made and the original type of organism was obtained.

Authentic cultures of *Bact. solanacearum* taken from tomato, egg-plant and castor bean were available and tomato seedlings, not more

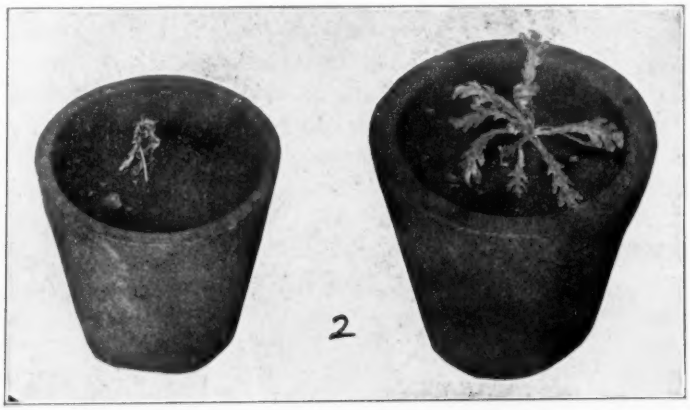

FIG. 2. Wilted and healthy tañgo seedlings. The plant on the left was inoculated through needle pricks in the stem with the tañgo organism about one week previous to the taking of the photograph. The plants were kept out of doors for the entire period.

than 10 centimeters in height, were inoculated with them as well as with a culture of the tañgo organism. In each instance the plants were inoculated through needle pricks and held in the damp chamber until the disease appeared.

After four days three seedlings inoculated with each organism wilted, and after six days all inoculated plants succumbed with the exception of one which had been inoculated with the tomato and another which had been inoculated with the egg-plant strain. The relative pathogenicity of each organism appeared to be about the same on this host.

Smith and other workers have frequently described the growth of adventitious roots near the point of inoculation, particularly on tomatoes and nasturtium. This phenomenon has never been observed locally but instead a more or less brownish lesion is formed at the point of inoculation which at first was believed to be caused by organisms other

than *Bact. solanacearum*. However, many inoculations have been made after washing the stem thoroughly with mercuric chloride and sterile distilled water and the lesion invariably appears.

The vascular tissue in the young plants inoculated with the tañgo organism turns brown and is identical with the vascular reaction of the solanaceous hosts.

CAUSAL ORGANISM

The organism isolated from tañgo is fundamentally similar to the organism isolated from tobacco, tomato, egg-plant, and castor bean and to the organisms used by Erwin F. Smith (2, 3) in cultural studies. The one consistent variation is in that of pigment production. When isolated from tañgo the organism produces but a very slight brownish coloration and that pigment which is formed is confined wholly to the bacterial growth.[1]

After the organism is passed through tomatoes the pigment producing power is regained but the color from the organism taken from tañgo directly, whether originally isolated from tañgo or tomato, never forms the deeper brown pigment.

The organism from tañgo has been grown in most of the differential media and complies with the published records of Smith (2, 3) giving the following cultural number, 2—.3333823.

MORPHOLOGY OF THE ORGANISM

The organism is very similar morphologically to the one described by Smith (2, 3). The rods are short, with rounded ends, measuring from .66 to 1.77 microns in length by .22 to .55 microns in width, the average measuring 1.22 by .42 microns. The organism stains readily with the common aniline dyes such as carbol fuchsin and methylene blue and shows a slight concentration of the stain at the poles.

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LOS BAÑOS, P. I.

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(3) ———. Bacteria in relation to plant disease **3:** 174–219. 1914. Carnegie Institution, Washington, D. C.

[1] During the second season of observation, the organism isolated from wilted *C. coronarium* frequently, but not invariably, produced the typical dark brown pigment of the organisms isolated from the solanaceous hosts.

A BRIEF HISTORY OF CITRUS SCAB IN JAPAN

TYÔZABURÔ TANAKA

Citrus scab is regarded by Japanese pathologists as a disease known in Japan from ancient times. Nishida,[1] referring to a letter of T. Tamura, states that the disease has been known on Kunembo (a mandarin closely allied to King orange), Satsuma and other kinds of oranges as a pathological ulcer-scab called Kahi and he refers to local Japanese names Abata Mikan (small-pox orange), Kasakaki Mikan and Kasa Mikan (both meaning syphilis-scab orange).[2] Ideta[3] also mentions that the disease was known in Japan from a long time past by the names Abata Mikan and Kasakaki Mikan. According to Hori,[4] the disease is the commonest of all citrus diseases in Japan and the growers of Kunembo and Tengu Mikan (a tangelo, probably a natural hybrid) have thought the scabbiness to be the characteristic of these oranges. Hori also states that the origin of the disease is unknown as we lack the record, but he suggests its probable origin from China with the introduction of nursery plants of citrus. Nishida first identified this Japanese disease as that called citrus scab in America and he gave the Japanese name "Sôkabyô," written originally in Chinese characters meaning syphilis scab disease, which is now generally recognized as the standard Japanese term for the disease. As was pointed out by the writer,[6] this paper of Nishida badly mixes up citrus canker and citrus

[1] Nishida, Tôji. Kankitsu no Shippei (Diseases of citrus fruits) in Kankitsu (Citrus fruits) 1 no. 3:3–4. M. 36, vi June, 1903. (Japanese). Also in Kankitsu Byôgaihen (A manual of citrus diseases) Shidzuoka, M. 40, v, May, 1907, p. 20–21. (Japanese). & Nishida's Shinpen Kankitsu Byôgai to Yobôhô (New discourse on citrus diseases and their prevention) Tokyo, T. 3, xi, Nov., 1914, p. 40–41. (Japanese.)

[2] There are no Chinese characters corresponding to these words, and they are all written in phonetic syllabaries of *Kana*.

[3] Ideta, Arata. Zôtei Nippon Shokubutsu Byôrigaku (Handbook of plant diseases of Japan) 4 ed. Tôkyô Shôkwabô, M. 44, 1911. p. 737–738. (Japanese)

[4] Hori, Shôtarô. Kankitsu Sôkabyôshi (History of citrus scab) *in* Hori's Shokubutsu Byogai Kôwa (Lectures of plant diesases) Tôkyô, Seibidô, T. 5, 1916, p. 280–289. (Japanese.)

[5] Nishida, Tôji. Kankitsu no Sôkabyô (Citrus scab) *in* Dainippon Nôkwaihô (Journ. Agr. Soc., Japan) no. 258: 1–4. M. 36, ii, Feb. 1903. (Japanese.)

[6] Tanaka, Tyôzaburô. A brief history of the discovery of citrus canker in Japan and experiments in its control (Quarterly Bull. State Pl. Board of Florida) 3 vol. 1. 1918, p. 3.

scab, but the former was later separated by the name "Marugata Sôkabyô" (Round scab) or, more definitely by the name "Kankitsu Kwaiyôbyô" (Canker of citrus).

The earliest occurrence of the Japanese name of citrus scab in the literature is probably in the work mentioned by the writer,[1] as Nankai Hôfu (Oranges of South sea district) written by Yoshiyuki Murase in 1818.[2] There are two scabby oranges mentioned in this work, one under the Chinese name "Shitôkan" (Lion-head orange) and the other "Reishikitsu" (Lychee orange), of which the second one bears the Japanese name "Kasa Mikan" in *Kana*. Very fortunately, the text of the description of Shitôkan was published by Ohara (see note 8), and it is the only description selected from the original manuscript work and printed. The comparison of this text and a figure attached to it, with those of the revised manuscript copy, shows that they are not exactly the same, and certain characteristics of the orange mentioned in the former are omitted in the latter. The page of text printed by Ohara, treating the Shitôkan or Lion-head orange, says "the size of fruit is large, about one foot in girth, two-tenth of a foot high,[3] with "Hirui"

[1] l. c. p. l.

[2] There is a bibliographic error in my citation of this work (7), which gives the name of the author as Yamanaka Shinko and the date of preface as 1865. The manuscript copy the writer has, gives S. Yamanaka as the author but this is an error. He merely made additions to the original text. The other copy in the Library of the Department of Agriculture (93 N 152) originally gave Yamanaka as compiler, but this was afterwards changed to read that he enlarged and corrected the work and Tôdô Ohara, is added erroneously as the original author. According to a published work of Tôdô Ohara, entitled "Tôdô Ihitsu" (Remaining works of T.d.) Vol. 2 pt. 2 (Book 6) fol. 15 (published in Kaei 3, 1849), the Nankai Hofu was written by Yoshiyuki Murase, in the 11th month (lunar calendar) of Bunsei 1, or 1818. His material was based upon collections made by Ohara's disciples from various places in the province of Kii, now called Wakayama-ken. The work has never been published, but was revised and enlarged by Shinko Yamanaka, having a preface dated 1865. Illustrations (colored paintings) originally made by Kunihiko Uetsuji in 1818, were added to this revised manuscript, and the atlas has an independent title "Kankitsu Dzue" (Illustrations of citrus fruits) and bears the preface and postface dated 1864 and 1867 respectively. This revised work entitled "Zôtei Nankai Hôfu," with Uetsuji's atlas, is the only one known at present and exists only in manuscript copies. Fortunately the original preface of Y. Murase (left out entirely in the revised copy), the table of contents and a page of text of the original work with a figure painted by Uetsuji, were published in Ohara's work. This shows that Murase's original description of citrus varieties is in Chinese, while the revised copy of Yamanaka is all translated into Japanese except the quotations from Chinese books.

[3] The measurement of height is omitted in the revised copy of Yamanaka.

(*Fei lo* in Chinese which means scrofula-ulcer)[1] on the rind looking very rough like a lion-head.[2] Even in mid-winter the peel remains green while the inside is quite red-ripe. It has a flavor similar to Kunembo, or better still, and the rind is as edible as in the latter variety . . . " It is also stated that this orange is locally called "Tô-kunembo" in the place where it is grown, but this name is often used, according to the author, to designate some other forms. So far as the illustrations of Uetsuji and the text of Murase go, this seems to be not a distinct variety of orange but merely a scabby Kunembo, such as are very commonly met with in the same locality at the present time.

Under the heading "Reishikitsu" (Lychee orange), the text of the revised manuscript Nankai Hôfu reads, "it resembles the Satsuma, but the peel is warty and has pimples (*Kotsutô* in Japanese, *ko ta* in Chinese)[3] on it, looking like the skin of the lychee fruit. It tastes good . . " The Japanese name given in the text is "Kasa Kôji" (Scabby Kôji orange), but the appearance of the fruit shown in the figure is quite far from typical thin-skinned yellow Kôji orange of very small size, illustrated elsewhere in the same work. The orange is very likely a scabby Satsuma. There is nothing else to which it can be referred.

These two kinds of scabby oranges were again treated in the well known work of Tsunemase Iwasaki, entitled "Honzô Dzufu." The work was completed in 1828 but it remained unpublished except for a few early volumes. The present facsimile edition[4] presents good proof that the scabby oranges are really diseased fruits. Under "Reishikitsu," it states that the orange is in size that of Kôji and is round, having thick, stiff skin with yellowish white pimples on the surface, giving the appearance of the lychee skin. The appearance of fruits and leaves illustrated is entirely different from that of Nankai Hôfu, and gives an impression of figuring some round-fruited mandarin infected by Citrus scab. Under "Shitôkan," two fruits with very pronounced lesions of citrus scab are illustrated; the text says that the orange is commonly planted in Suruga province; the fruit resembles Yuzu somewhat flattened with a reddish-yellow skin covered with green pimples looking like the back of a toad; the pulp is sweet. A leaf

[1] *see* Giles Chinese-English dictionary, 2d ed., nos. 3468 and 7287.

[2] The lion-head, commonly impressed from the image carved in stone and placed in front of shrines, is very warty in appearance, as the name is represented by repeated tuberose protrusions covering the whole surface.

[3] *see* Giles Chinese-English dictionary, 2d ed., no. 6050.

[4] Iwasaki, Tsunemasa. Honzô Dzufu (Illustrated herbal). new ed. supervised by M. Shirai & K. Onuma. published by Honzô Dzufu Kwankôkwai, Tôkyô. *see* Book 62 fol. 7 & 11, issued T. 8, iv, Apr. 1919.

illustrated bears a broad petiole wing, but the text denies the presence of it, so that it is difficult to determine whether this is a Satsuma or a Kunembo.

There seems to be no scientific account in Japanese literature of the fungus causing the citrus scab before Nishida,[1] who gives *Cladosporium citri* Mass. as the causal organism. Shirai,[2] on the other hand, considers *Cl. elegans* Penz. to be the fungus causing "Mikan no Kasa" (Syphilis-scab of oranges). Yoshino[3] apparently collected the specimens of both citrus scab and citrus canker. He gave *Cl. citri* Mass.? as the cause of scab, and *Cl. elegans* Penz.? as the cause of canker. Shirai and Miyake,[4] however, mention both species as causing citrus scab, though many Japanese writers maintain that the real organism causing citrus scab is uncertain.

Citrus scab is distributed all over Japan, but the severity of infection is not equal in all places. According to the writer's field observations, the citrus groves in Ehime prefecture show almost no severe infections of citrus scab, while the orchards of Oita prefecture in Kyûshû, notwithstanding they are located only 30 miles away across the channel, are very severely infected.

The disease is also widely distributed in Formosa, as evidenced by the report of Formosan Agricultural Experiment Station,[5] stating that Kankitsu Sôkabyô (*Cladosporium citri* Mass.?) affects leaves and young stems of citrus, collected from 20 different places in the island. Hori[6] also mentions that the disease is common in Bonin and Formosa.

[1] Nishida, T. *see* work mentioned in note (5), p. 3.

[2] Shirai, Mitsutarô. Nippon Kinrui Mokuroku. A list of Japanese fungi hitherto known. Tôkyô, M. 38, xi, Nov., 1905. p. 21.

[3] Yoshino, Kiichi. Higo Kokusan Kinrui (Fungi collected in Higo province) in Shokubutsugaku Zasshi, Bot. Mag. (Tôkyô) 19 no. 224: 219. M. 38, ix, Sept., 1905. (Japanese.)

[4] Shirai, M. & Miyake, I. Nippon Kinrui Mokuroku. A list of Japanese fungi hitherto known. 2 ed. Tôkyô, T. 6, xi, Nov., 1917. p. 135–136.

[5] Taiwan Sôtokufu Nôji Shikenjô (Governm. Gen. Form., Agr. Exp. Sta.) Taiwan Nôsakumotsu Byôgai Mokuroku. List of fungi on cultivated plants o Formosa, Part 1. (Division of plant pathology Bull. no. 1.) Taihoku, M. 41, ix, Sept., 1908. p. 39–40.

[6] Hori, S. *see* work mentioned in note (4). p. 281.

TAXONOMY OF THE SCLEROTINIA ON HELIANTHUS ANNUUS L.

EDITH SEYMOUR JONES

WITH ONE FIGURE IN THE TEXT

OBSERVATION AND DESCRIPTION OF THE DISEASE

A wilting of sunflower plants was recorded from Wisconsin for the first time in July, 1918, when it was found at Madison. In 1919 and 1920 several groups of wilted plants were found at Ashland in fields where sunflowers were grown for silage.[1] An examination of the plants during the early stages of attack showed that the first evidence of the disease was a scalded area at the base of the stem which in moist weather was covered by a white mycelial mat. In dry weather, a wilting and burning of the leaves developed, followed a few days later by a rapid extension upward of the diseased area for a distance of about one foot. When the infected plant had completely wilted, sclerotia began to form on the outer surface of the stalk. The mycelium was found to have penetrated through the epidermis into the parenchyma surrounding the bundles and into the central pith where, as also among the roots, sclerotia had developed abundantly. In the diseased region the fungus had reduced the stem to a mere mass of vascular bundles surrounded by some disintegrated parenchyma. The disease was more prevalent where there was a thick stand of plants and where sunflowers had been grown successively for a number of years. The progress of the disease was favored by moist, cool weather. The soil in the Madison garden where the disease occurred was a clayey loam, quite moist, and very heavily fertilized.

OBSERVATIONS OF A SCLEROTIAL DISEASE ON SUNFLOWER IN AMERICA

American literature shows that a sclerotial disease of sunflowers has gained importance with increased sunflower culture in the northwestern states. As early as 1890 it was observed by Pammel (15) in Iowa. The plant disease surveys of the United States (8) and Canada (16) in 1921 both reported the common occurrence of the same disease, recording it in Oregon, Washington, Minnesota, and Ontario. The plant disease survey for Canada (10), published in 1922 contains a note by Cunningham who found *Sclerotinia libertiana* Fckl. on sunflowers

[1] These observations were made by Dr. J. G. Dickson.

and also records a root rot on sunflower seemingly distinct from the disease caused by Sclerotinia. Lawrence (13) in Washington, Morris and Swingle (14) in Montana, and Bisby (3, 4) in Manitoba have studied the disease. The description which they have recorded agrees with that of the disease observed by Dr. Dickson.

In regard to the taxonomy of the causal fungus, Pammel suggests that the sclerotia resemble those of *Sclerotinia sclerotiorum* (a synonym for *Sclerotinia libertiana* Fckl.). Morris and Swingle and Bisby agree that the causal organism resembles *Sclerotinia libertiana* Fckl. Bisby and Buller (5), in their list of Manitoba fungi, record what is considered to be *Sclerotinia libertiana* on *Helianthus annuus* (cult.). Lawrence, on the other hand, without referring to any previous observations of Sclerotinia on sunflower, describes the fungus as a new species under the name, *Sclerotinia perplexa*. His description differs from that of *S. libertiana* as given by Fuckel only in the addition of a conidial stage which he found upon the host plant and from which he grew sclerotia in culture. Since, except for Lawrence, the Americans have not clearly stated the taxonomy of the fungus causing the disease, it seemed worth while to study the fungus with a view to determining its taxonomic position.

INOCULATION EXPERIMENTS AND DEVELOPMENT OF THE PERFECT STAGE

The fungus isolated from the diseased sunflower stalks was inoculated into young sunflower and lettuce plants. In the sunflower the disease which was observed in the field was readily reproduced (FIG. 1). The lettuce wilted rapidly, showing the typical symptoms of lettuce drop. Sclerotia obtained both from sunflowers in the field and from inoculated plants were placed for overwintering below the surface of moistened quartz sand in covered flower pots which were buried in the garden two feet below the surface of the soil. In May the sclerotia were found germinated.

The following is a description of the perfect stage made unfortunately after the apothecia had been kept for some time in alcohol.

Fruiting bodies numerous, stipitate, smooth, light-brown, funnel-shaped, 0.9 to 3.0 μ in diameter; stipe slender, straight, sometimes bent one or more times; sclerotia irregular tending in general to be somewhat tuber-like in form, at times elongate, black externally although sometimes covered with white mycelium, cream colored within; asci cylindrical, hyaline, 66 to 136 by 6 to 7.4 μ; spores monostichous, ellipsoid, 7.4 to 11 by 3.7 to 4.6 μ; paraphyses filiform.

This description agrees closely with Fuckel's description of *Sclerotinia libertiana* as quoted by Saccardo (17). The most important difference

between this description and that of Fuckel consists in slightly smaller spore measurements, the spores under observation measuring 7.4 to 11 by 3.7 to 4.6 μ in contrast with Fuckel's measurements 9 to 13 by 4 to 6.5 μ. In this connection, however, it is of interest to note that

FIG. 1. The effect of inoculation of sunflower plants with *Sclerotinia libertiana*. Photograph taken 12 weeks after inoculation. Uninoculated plant at left. a. sclerotium.

deBary (2) found that fresh spores of *S. libertiana* measured 11 to 12 by 4.5 to 6 μ, whereas spores from material dried or kept in alcohol were only about 9 by 4.5 μ. DeBary's measurements of ascospores preserved in alcohol are identical with the mean of the measurements given in the description above, thus leaving no reason to doubt that this fungus is *S. libertiana*.

In connection with this determination of *Sclerotinia libertiana* on sunflower it is of interest to note that there are many European records of this fungus upon the same host. As early as 1861 Fuckel (9) describes the perfect stage of *Sclerotium compactum* DC. b. *Helianthi* Rabh. *Sclerotium compactum* DC. was later shown to be the sterile condition of *Sclerotinia libertiana* Fuckel. In 1876, Brefeld (6) describes the parasitizing of *Helianthus tuberosus* by a Peziza-forming sclerotium. Frank (7) in 1897 records *Sclerotinia libertiana* on the same host. DeBary (2) in 1886 found the same fungus twice on stalks of *Helianthus annuus* although he says that Sclerotinia rarely occurs on Helianthi. Kirchner (12) records *S. libertiana* on sunflower in 1897. Saccardo (17) gives *S. libertiana* on *Helianthus annuus*. Of the two more recent observations, Jachevski (11) in 1921 in Russia records the continual extension of injury to sunflower and other kitchen-garden plants from *S. libertiana*, and the Journal of the Board of Agriculture (1) of Great Britain in 1917 publishes a record of sunflower as a host of *Sclerotinia sclerotiorum* (syn. *S. libertiana*). The evidence brought together here indicates beyond a doubt that the disease of sunflower of Europe caused by *Sclerotinia libertiana* is identical with that which has been encountered most frequently in America.

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FUNGI ISOLATED FROM THE INTERIOR OF COTTON SEED

R. F. CRAWFORD

The cotton seed used in this experiment was selected from badly wilted plants during the later part of September, 1921, by Dr. J. A. Elliott of the Arkansas Experiment Station. The chief object of the experiment, as reported by Elliott (3), was to determine whether or not cotton wilt was carried in the seed. Several other fungi made their appearance from time to time during the experiment, some of which have not been reported as being seed borne. The cotton seed was delinted with concentrated sulphuric acid, washed thoroughly, dried and stored in a cloth bag. At the time of planting the seed was again charred in sulphuric acid, treated for two minutes in a 1–1000 solution of mercuric chloride, and washed in sterile water. The plating was done on white blotting paper, which was dampened, placed in petri dishes, and sterilized in an autoclave for one hour at 15 pounds pressure. It would seem hardly possible that any external organisms could survive the treatment given the cotton seed, and all fungi reported are considered as coming from the interior of the seed.

TABLE 1—*Fungi isolated from cotton seed.*

Series	Date	No. of seeds	Fusarium vasinfectum		Colletotrichum	Diplodia	Fusarium No. 1[1]	Fusarium No. 2[1]	Fusarium No. 3[1]	Cephalothecium	Alternaria
A	9/27/21	105	4		11	1	0	4	0	1	0
B	2/28/21	119	5		13	1	0	7	1	1	0
C	10/ 6/21	150	6	+11	14	0	0	5	1	0	0
D	10/16/21	150	5		11	0	2	1	0	0	2
E	10/25/21	150	5		18	0	8	1	0	0	0
F	12/12/21	95	3		20	0	17	0	0	0	0
G	1/17/22	100	1		20	0	23	6	0	0	0
H	2/16/22	200	4		72	0	30	7	0	2	0
I	3/14/22	200	1		54	2	28	3	0	2	0
J	4/17/22	200	1		41	9	15	14	0	1	1
	Total	1469	46		274	13	123	48	2	7	3

[1] With the exception of *Fusarium vasinfectum*, no specific name has been given to the Fusaria found. Cultures of each have been sent to Dr. C. D. Sherbakoff for identification.

The increase in the number of isolations of certain of the fungi in the later platings was undoubtedly due to the fact that at first only apparently viable seed was selected, while in the last five platings the seed was unselected and contained a considerable amount of dead and shriveled seed which was naturally more apt to carry the facultative parasites or saprophytes.

Colletotrichum.—To establish the pathogenicity of the *Colletotrichum sp.* isolated from the interior of the cotton seed, healthy cotton bolls in various stages of maturity were brought into the laboratory and inoculated with a pure culture of the fungus. These inoculations were made by transferring some of the spores into a wound in the boll made with a sterile knife. Successful inoculations producing the characteristic anthracnose boll-rot were obtained in all cases, as had been done in experiments by Barre (1), Edgerton (2), and others with *Glomerella gossypii* isolated from the interior of the cotton seed.

Diplodia gossypii.—The disease caused by this fungus was discovered and described by Edgerton (2) of the Louisiana Experiment Station, but no mention is made in the literature of its being seed borne. Elliott (4) states the possibility of its being carried on the seed. All the cultures of Diplodia were isolated from the interior of dead seed. A number of cotton bolls were inoculated by means of needle punctures with pure cultures of the fungus. In a few days after inoculation, the bolls first became brown, and shortly after, pycnidia and spores could be found on the surface. The entire boll would soon be covered with a jet-black powdery coating of spores. The rot progresses very rapidly, involving the entire boll and destroying the lint. Dr. C. W. Edgerton, in conversation with Dr. J. A. Elliott, suggested the possibility that cotton and sweet potato Diplodia were similar, if not identical. Inoculations were made on sweet potatoes with the cotton Diplodia and positive results were secured. The disease did not progress nearly as rapidly on the sweet potatoes as on the cotton. The sweet potatoes were slowly rendered dry, hard, and brittle, with a coal black interior. The typical pycnidia and two-celled brown spores were found on the surface of the sweet potato.

Fusarium No. 1.—This Fusarium has a peculiar lemon-shaped sporangium-like body and a very coarse mycelium. It has been under observation for some time and produces macroconidia very sparingly. On rice the Fusarium produces a dark brown color. This fungus is evidently the same as has been observed by Dr. C. W. Edgerton of the Louisiana Experiment Station. In a letter Dr. Edgerton states: "I remember distinctly of obtaining a fungus with peculiar sporangium like bodies,

which I was never able to develop any further." No inoculation experiments have been conducted with this Fusarium.

Fusarium No. 2.—This fungus, commonly found on and in cotton seed, appeared to be identical with the one reported by Edgerton (2) as very common on rotting bolls, especially in wet weather. The mycelium is apparently able to grow into the kernel of the seed and remain in a dormant condition during the winter. In the spring when the seed is planted the fungus forms spots on the cotyledons. This Fusarium was isolated from spots on the cotton leaves both in the field and greenhouse as well as from the interior of cotton seed. Field observations would indicate that a large percentage of young seedlings have these Fusarium spots on the cotyledons. Inoculated bolls show a slight staining of the lint and eventually may become entirely rotted. Injury to the bolls, such as caused by insects or the angular leaf-spot organism, is apparently necessary for infection.

Fusarium No. 3.—The first mention in literature of this Fusarium is by Elliott (4) who describes it as causing a rapidly progressing bright pink rot of cotton bolls. Throughout the experiment, some of the young seedlings, that did not show any fungous growth, were removed from the petri dishes and transferred to test tubes containing an inch of agar. Two of these plants developed fungous growth which stained the potato agar slants, on which they were growing, a bright pink far below the growth of the mycelium. Cotton bolls in all stages of maturity were successfully inoculated in the laboratory. The rot progressed with great rapidity and soon destroyed the whole boll, producing a characteristic bright pink color of the lint. This Fusarium produces a rot of the bolls about as quickly as does the Diplodia boll-rot fungus.

Two other fungi, a species of Cephalothecium, and an Alternaria, were isolated but no studies or inoculation experiments were conducted with them.

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PHYTOPATHOLOGICAL NOTES

Gum diseases of sugar cane in the Philippines. Miss Wilbrink[1] has pointed out the occurrence in Java of a bacterial disease, the symptoms of which are red vascular bundles, sudden wilting of the leaves from the tips in longitudinal whitish streaks, and the production of numerous shoots from the lateral buds of the standing cane. The disease is identical to Cobb's gum disease of sugar in Australia with the exception that in Java there is no yellow bacterial ooze from the cut vascular bundles as is the case in Australia.

In a previous publication, Lee[2] reported an unidentified disease from the Philippines which for convenience was at the time termed red-vascular disease. The identity of the disease was uncertain at the time, due to the absence of the yellow ooze reported for gum disease by Cobb[3] and others.

A recent visit to Java has shown the identity of the Philippine red-vascular disease with the bacterial cane wilt in Java; there is the same whitish longitudinal streaking of the leaves, sudden wilting, reddened vascular bundles and varietal susceptibility. Bacteria can be seen in masses in sections of the vascular bundles of affected cane under the microscope. Bacteria show up uniformly in dilution plates which agree with Miss Wilbrink's description of the Java vascular organism, although our inoculation experiments are not sufficiently extended in time to enable us to state that we have reproduced the disease by inoculation. This disease in our experience in the Philippines attacks the varieties H-109, Lahaina, Negros Purple and Louisiana Striped very severely. We have not seen it on the Badila variety nor on the Caledonia canes.

With the determination of this disease we are able to point, not entirely with pride, to the presence in the Philippines of all but two of the important diseases of sugar cane known in the literature. These two, sereh and Lahaina disease, may show up with further experience.—H. ATHERTON LEE.

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Leaf cast of Larix occidentalis by Hypodermella laricis Tubeuf in north Idaho. The disease of western larch known as leaf cast (*Hypodermella laricis* Tubeuf) has been previously reported from Idaho by various writers. However, it appears as if the importance of the disease has not

FIG. 1. *Hypodermella laricis* killing short spurs of *Larix occidentalis*.

received sufficient attention. The purpose of the present note is to emphasize the fact that *Hypodermella laricis* does more damage than merely killing the needles in that it very often kills great numbers of the short spur-like branches which bear the needles.

The common name "leaf cast of larch" as applied to this disease is a misnomer in that exactly the opposite phenomenon is produced. The

infected leaves instead of being deciduous remain on the tree until the following year and become quite conspicuous early in the growing season in contrast with the new leaves.

During the last four years, the writer has noted the general distribution of the disease in north Idaho but during the summer of 1922 the infection appeared to be particularly severe. An idea of the severity of the infection may be conveyed by the appearance of a young stand of larch in the small sapling stage in midsummer. Last year many such stands appeared as if a fire had passed through them and these stands, when viewed from a distance, did not even have a greenish cast.

On examining such a stand again this spring after the new growth of needles had been produced, it was observed that many of the short spur-like branches, which still had last year's infected needles attached to them, were not producing new needles and that they had been killed. A count of five branches, picked at random, bore a total of 593 leaf-bearing spurs of which 29 per cent or 172 had been killed. On one of these branches having a total of 199 leaf-bearing spurs, only 121 were producing needles, the remainder, 78, had been killed. Dead branches are also quite common on badly infected trees and there is little doubt that they had been killed by the fungus under discussion.

This reduction in the leaf area must be reflected in the rate of growth of the infected trees. In the writer's opinion *Hypodermella laricis* causes an important disease of western larch and should be given detailed study. In figure 1 the dead, leaf-bearing spurs with last year's infected needles are plainly visible. This specimen was collected May 11, 1923.—HENRY SCHMITZ.

THE FIFTH ANNUAL SUMMER MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The fifth annual summer meeting of this Society, which was held in western New York and Ontario, Canada, during the four days from July 9 to 12, 1923, inclusive, was most successful. The weather was perfect; the attendance was good, there being present sixty-nine members of the Society and about twenty guests; the automobile transportation facilities were excellent; and the program, arranged by the Advisory Board, with M. F. Barrus and J. H. Faull in direct charge of the itineraries for New York and Canada, was interesting and well conducted. The two local committees who had charge of the plans deserve much credit and have the thanks of the Society for their commendable work.

On the first day of the meeting the gardens, orchards and equipment of the New York Agricultural Experiment Station at Geneva, and experimental apple orchards in the vicinity were inspected. On the following day automobiles conveyed the party from Geneva to Rochester by the way of Lyons, Sodus, Williamson, and Irondequoit, frequent opportunities being provided for observing diseases of wheat, raspberries, apples, cherries, lettuce, onions, greenhouse cucumbers, tomatoes, and other crops. On Wednesday, July 11, the tour was continued through the extensive western New York fruit belt to Niagara Falls by way of Hilton, Albion, Medina and Middleport. During this part of the trip apples, cherries and raspberries particularly were examined for diseases. On July 12 the party was entertained by officials of the Canadian Department of Agriculture, the Ontario Agricultural College and the fruit growers of the Niagara Peninsular section. Stops were made at about seven places between Niagara Falls and Hamilton, Ontario, including a visit to the Experiment Station of the Province of Ontario at Vineland. The large variety of fruits that are grown very intensively in this section, although in general remarkably free from diseases, were of much interest to the visiting pathologists. The meeting culminated with a complimentary banquet provided by the Dominion Department of Agriculture at the Royal Connaught Hotel in Hamilton.

One of the main features of the meeting was the excellent opportunity provided for studying raspberry diseases of the yellows type, that is, mosaic, leaf curl, and the so-called eastern blue-stem or rosette. Plenty of diseased plants were available for study and the pathologists who have done the most work on these diseases were present to give explanations concerning them. A field where roguing for control of mosaic and leaf curl has been practiced was remarkably free from the disease.

Another important line of work, the results of which were inspected in four orchards, was the apple spraying and dusting experiments of the Geneva and Cornell Experiment Stations. Among the preparations under investigation were sprays and dusts to which various kinds of stickers had been added, colloidal and precipitated sulfur as prepared by H. C. Young, and nicotine sulfate and tobacco dust in combination with various sprays and dusts for red bug control. In the Cornell experiment at Sodus a very good example of the importance of the timeliness of the pre-blossom spray for scab control was noted.

At Williamson, N. Y., the onion breeding and smut control plots were of much interest, and the visits to the Niagara Sprayer Company at Middleport, N. Y., and the fruit packing plant of Senator E. D. Smith at Winona, Ontario, deserve especial mention.

Of the diseases that were observed, perhaps the following were most interesting: mosaic, leaf curl, eastern blue-stem, powdery mildew (undet.) and cane blight (*Leptosphaeria coniothyrium*=*Coniothyrium fuckelii*) of raspberry; orange rust (*Kunkelia nitens*) of blackberry; *Fomes ribis* on currant; leaf spot (*Mycosphaerella fragariae*), leaf scorch (*Mollisia earliana*), root rot (undet.) and winter injury of strawberry; fire blight and scab on apple; leaf spot (*Coccomyces hiemalis*) of cherry; mosaic, tipburn, bottom rot (*Rhizoctonia sp.*), drop (*Sclerotinia libertiana*) and Botrytis rot (*Botrytis sp.*) of lettuce; smut (*Urocystis cepulae*) and pink root (*Fusarium sp.*) of onion; and take-all and other diseases of wheat. The stem nematode (*Tylenchus dipsaci*) was found for the first time in the eastern United States on the common dandelion by G. H. Godfrey during the course of this field trip.

The following resolution, presented by a Resolutions Committee, was adopted:

To whom it may concern:

The members of the American Phytopathological Society appreciate very much the many courtesies shown them by the different groups and individuals during the occasion of the Fifth Annual Summer Meeting of this Society, and we hereby formally wish to express and convey that appreciation, especially to the officers and staff of the New York Experiment Station, Geneva, to the staff of the Extension Service and Plant Pathology Department of the Agricultural College, Cornell University, under the kindly and efficient leadership of Profs. M. F. Barrus and H. E. Thomas, to the Dominion of Canada Department of Agriculture and to the Ontario Department of Agriculture, especially the officers and staff of the Vineland Experiment Station, to the Agricultural Representatives and fruit growers of the Niagara District, Ontario, to Prof. J. E. Howitt, Ontario Agricultural College, Guelph, to the Monroe County Farm Bureau under the leadership of Mr. E. G. Smith, to the Sodus Fruit Farm, Inc., Sodus, N. Y., to the Hon. Senator E. D. Smith, Winona, Ontario, to Mr. F. L. Strickland, Lockport, N. Y., and to the Niagara Sprayer Company.

The Committee on Resolutions requests that this note of appreciation be spread on the minutes of the Society and a copy be sent to each of the above-mentioned organizations and individuals.

Signed:

S. M. ZELLER, Chairman.
CHARLES CHUPP,
G. H. COONS,
Resolutions Committee.

R. J. HASKELL,
SECRETARY, ADVISORY BOARD
OF AMERICAN PLANT PATHOLOGISTS.

ABSTRACTS OF PAPERS PRESENTED AT THE FIRST ANNUAL MEETING OF THE INLAND EMPIRE SECTION, PACIFIC DIVISION, AMERICAN PHYTOPATHOLOGICAL SOCIETY, PULLMAN, WASH., AND MOSCOW, IDAHO, FEBRUARY 8 AND 10, 1923.

At a meeting held at Pullman, Washington, February 3, 1923, at which were present the plant pathologists of Washington State College and the University of Idaho, the following program was given by the members from Washington State College.

Botrytis diseases in Washington. B. F. DANA.

The following diseases as they have occurred in Washington have been assigned to *Botrytis cinerea* Pers: Apple fruit rot, carrot storage rot, cranberry fruit rot, fig canker, ginseng moldy seed, gooseberry dieback, lettuce gray mold, lilac leaf blight, peony blight, pear, plum, raspberry, and strawberry fruit rots, and squash storage rot. Onion neck rot, *B. alii* Munn., peony blight, *B. paeoniae* Oud., and tulip blight, *B. parasitica* Cavara have also occurred in Washington within the last eight years. During the same time the following diseases caused by unassigned species of Botrytis have occurred: eggplant fruit rot, golden seal leaf blight, periwinkle leaf blight, rose blossom blight, and snowball blossom blight.

Notes on Rhizoctonia. B. F. DANA.

Experimental work on potatoes at Pullman has shown that selection of visibly clean seed stock will give the largest quantity of table stock. If this clean seed is treated with mercuric chloride it will increase the yield of clean tubers in the table stock. In one experiment infected untreated seed gave 9 per cent, infected treated, 59.5 per cent, and clean treated seed gave a yield of 80 per cent clean table stock. Mercuric chloride has proven superior to formaldehyde against Rhizoctonia. The following results of one test are representative. Infected untreated seed yielded 50 per cent clean table stock. Treatment with formaldehyde and mercuric chloride increased the yield of clean table stock to 73 and 84 per cent respectively. Treatment of seed with mercuric chloride, four ounces to thirty gallons of water for two hours, has not increased yields in potatoes treated just before planting. Shortening the time of treatment gave lessened control even when double strength or eight ounces of mercuric chloride to thirty gallons of water was used.

Spraying with Bordeaux mixture at Pullman and Yakima and soil fertilizer treatments at Pullman did not consistently increase the yield or per cent of clean tubers in the crop. Late spring plantings at Pullman gave a higher yield of clean tubers in the crop from infected seed than early spring planting under the same conditions.

Preliminary report on rots of the cranberry in Pacific County. D. J. CROWLEY.

During the past season the writer made an investigation of the fungous diseases of the cranberry in Pacific County, Washington, and also carried out a series of spraying experiments to determine the best means for their control. Very little rot showed in the bogs during the growing season, but soon after the berries were placed in storage,

they started breaking down rapidly. Later work in Pullman showed that the following organisms were responsible for the storage rots: *Fusicoccum putrefaciens* Shear; *Guignardia vaccinii* Shear; *Pestalozzia guepinii vaccinii* Shear; *Sporonema oxycocci* Shear; *Sporonema pulvinatum* Shear; *Anthostomella destruens* Shear; *Phomopsis sp.; Stemphylium sp.; Botrytis sp.* Storage of berries at 32° F. reduced the storage losses by about one-half. Further investigations are still being carried on.

Coryneum blight of stone fruits in Washington. CHAS. S. PARKER.

This disease was shown to be of economic importance periodically in parts of the State of Washington. By means of artificial inoculations and re-isolations all of the typical symptoms of the disease as observed in the orchards were reproduced within the greenhouse or laboratory. Experiments involved the use of peach, apricot and cherry hosts. *Coryneum beijerinckii* Oudem. was demonstrated to be the causal organism. Infection was found to take place only through the stomata or ruptured epidermal tissue of leaves. The fruiting body was shown to be an acervulus, which was readily reproduced on twigs of the host plants, but never on dextrose or prune agar. Spores upon the natural matrix will resist unfavorable conditions for a very extended period. After nineteen days of desiccation spores germinated within twenty-four hours.

Notes on the anthracnose of lettuce. CHAS. S. PARKER.

In the fall of 1922 volunteer head-lettuce plants showing this disease were transferred in flats from the open garden to greenhouse. *Marssonia panattoniana* (Berlese) Magnus was isolated and grown on 3 per cent dextrose agar plus ten. During the winter months, by means of an atomizer, spores from the pure culture were sprayed over the leaf surfaces of *Lactuca scariola* L., which were growing in the greenhouse, and a perfect infection was obtained. Early in the spring of 1923, typical anthracnose lesions were observed along the mid-rib of *Lactuca scariola* L. growing in the open as a weed. Isolations made from this material were growing well in pure culture when a sudden increase in temperature due to exceptional warm weather killed this material and the pure cultures from the cultivated lettuce.

Fusarium rot of onions. L. W. BOYLE.

A brief statement was presented of the onion rot problem of the Walla Walls truck district of Washington. The rot occurs in the field but is most important in storage and transit, causing heavy losses. Specimens from the field showed wilted and brown soft tops. The bulbs, however, showed no rotting about the necks except in very advanced stages. Certain specimens appeared perfectly normal until cut. Starting at the base and extending various distances up individual scales, the tissues had a solid watersoaked appearance. The soft rots were likewise limited to individual scales and the tissue had a brown slimy appearance. This condition also started at the base and was apparently following up the individual scales after the before-mentioned watersoaked condition. The roots were still attached but in many cases easily brushed off. Specimens of the rot in the advanced stage, where a large part of the bulb was soft, had a heavy ring of white fungous growth about the base. This invariably was producing Fusarium spores. Bacteria and fungi were isolated from the soft brown rotted tissue near the base of bulb scales, and pure Fusaria cultures were isolated from the more solid tissue at the edges, in advance of the soft brown tissue. Methods of isolation and inoculation were described. Further work is necessary to determine whether bacteria or fungi alone, or together, cause the rot.

Further observations on the relation of the spore load to the per cent of bunt appearing in the crop. F. D. HEALD AND L. W. BOYLE.

To be published in full in PHYTOPATHOLOGY.

The copper carbonate bunt problem. F. D. HEALD.

A brief review was presented of the work carried out on the copper carbonate dust treatment for bunt or stinking smut of wheat, with a presentation of the features in which the new treatment shows a superiority over the old wet methods of seed disinfection with bluestone or formaldehyde. Special emphasis was given to the complete elimination of seed injury by the use of copper carbonate. Several lots of seed treated a year ago gave better germination than untreated seed. Copper carbonate treated grain invariably has shown a greater vigor of growth and the protection against smut has been better than when formaldehyde is used, and equal to or better than when bluestone has been employed.

Many different commercial brands of copper carbonate are now on the market and one of the present problems is the determination of what specification should be demanded. The different brands differ in purity, specific gravity and fineness. Two ounces of Corona Compound per bushel, testing from 17 to 21 per cent of metallic copper, has given practically as good protection in spring plantings as pure copper carbonate, testing fifty or more per cent of metallic copper.

The following week, February 10, 1923, those interested in plant pathology, from the two institutions, convened at Moscow. At this meeting the final organization of the Inland Empire Section, Pacific Division, of the American Phytopathological Society was completed. There were twenty-six present. The following officers were elected:

President, F. D. Heald.
Vice-President, C. W. Hungerford.
Secretary-Treasurer, J. M. Raeder.

The following program was given by the Idaho representatives:

Studies in wood decay V. Physiological specialization in Fomes pinicola Fr. HENRY SCHMITZ.

The results obtained from a physiological study of four cultures of *Fomes pinicola* Fr., obtained from four different hosts, namely, Douglas fir, (*Pseudotsuga taxifolia*), white fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), and western white pine (*Pinus monticola*), were reported. The results obtained show that these four strains of *Fomes pinicola* differ very markedly in (1) the characteristics of growth, (2) the rate of growth, (3) the extracellular enzyme activity, (4) the intracellular enzyme activity, (5) the effects produced in mixed cultures, (6) the growth in liquid media and (7) the nitrogen relations.

The distribution of Ribes and five-needle pine in the Okanogan region of Washington and British Columbia. V. H. YOUNG.

Preliminary results of experiments with leaf roll and mosaic in Idaho. CHAS. W. HUNGERFORD.

Bliss Triumph potatoes from mosaic free stock were grown under cloth cages and various insects were introduced into these cages after having fed upon mosaic diseased plants. The following insects were used: green peach aphis (*Myzus persicae* Sulz),

pink and green rose aphis (*Macrosiphum solanifolii* Ashmead), a false chinch bug (*Nysius ericae* Shilling), tarnish plant bug (*Lygus pratensis* Linn.) and several others. Positive results were secured with the pink and green rose aphis only. Characteristic mottling developed three weeks after the aphids were introduced into the cages. All the checks remained healthy. Tubers from these infected plants were later grown in the greenhouse and in each case at least some of the tubers from each hill produced badly diseased plants. In one case four small tubers from one of these plants were planted in the greenhouse. Two of these produced apparently healthy plants while the other two were badly diseased. Small potato seed plots grown in various parts of the state from selected seed of the same seed lot developed varying amounts of mosaic when grown in different localities. This apparently would indicate either that mosaic symptoms were masked under some climatic conditions or else local sources of infection from other fields or from wild hosts were present in some cases and not in others. This work is being continued upon a larger scale this year.

Results of tests with copper carbonate in Idaho. CHAS. W. HUNGERFORD.

Tests have been made the last two years with several dust treatments for the control of stinking smut. None of these treatments have given as good control of smut as the standard bluestone treatment under the conditions where they have been tried. Three different commercial brands of copper carbonate were used. None of these gave as good control as bluestone. Germination, however, was better in every case where copper carbonate was used. In small experimental plots the stand was better in each case where copper carbonate was used than in the check plots. These tests are being continued in cooperation with a large number of farmers in various parts of the state using a number of commercial brands of copper carbonate and a number of mercury compounds.

The effect of pre-sprinkling with water on the hot formaldehyde and corrosive sublimate methods of potato seed treatment. J. M. RAEDER.

Further laboratory results this year indicate that the efficiency of both the hot formaldehyde and the corrosive sublimate treatments for seed potatoes is increased by first sprinkling the potatoes with water and then covering them for 24 or 48 hours. As compared with last year's results, this difference was not so marked. Results last year showed complete control with six different methods of treatment with hot formaldehyde subsequent to sprinkling. This year absolute control was obtained in only four such cases. The results of this work will soon be published in full.

Preliminary results with the use of sulfur for the control of potato scab in Idaho. J. M. RAEDER.

This work was conducted on but one acre of ground divided into thirteen plots, five of which were checks. The average pH value of the soil of these checks was 6.74. Although the pH value of the soil of some of the plots was materially reduced, the results obtained at digging time showed that control was negative. This work will be conducted on a larger scale during the coming year.

The October number of Phytopathology was issued October 19, 1923.